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"Nintendo BrainAge 2: Improving Cognition in Stroke Survivors"

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Capstone Approval Page

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"Nintendo Brain Age 2: Improving Cognition in Stroke Survivors"

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Purpose: My capstone project was part of a larger study being conducted by Dr. Jamie Mayer at Northern Illinois University. The purpose of this study was to determine if consistently playing an educational videogame could improve memory, cognition and executive function in people who have had a stroke or brain injury. **Background:** Recent research in neural plasticity of brain function has provided evidence that after injury, the brain can compensate for damaged areas through plastic changes. Observational studies performed by Butcher (2008) showed consensus that consistent cognitive practice from Brain-Age 2 helped deter the onset of dementia. The amount and intensity of therapy critically affects how much a patient will benefit from therapy. Particularly with cognitive tasks, more training leads to more improvement (Jaeggi et al. 2008). What has not been investigated is whether cognitive stimulation, known to be helpful in preventing or delaying the onset of dementia in those with normal cognition or mild cognitive impairment, can actually help to increase or restore certain cognitive processes in those with cognitive problems secondary to stroke or brain injury. **Hypothesis:** After 6 weeks of consistently playing the Nintendo Brain-Age 2, stroke survivors' cognition and memory will improve to a measurable degree. **Results:** The results of the analysis showed no significant changes from pre-assessment to post-assessment, nor were there any changes within control subjects or stroke survivor subjects. **Discussion:** Incorporating strategy training as a component of this study may produce measurable changes in both control and stroke subjects. Different assessments may reveal changes that we did not pick up on. Finally, the game seemed too easy for control and mild stroke subjects, which produced ceiling effects, and too hard for severe stroke subjects. **Conclusion:** Consumers should take caution before buying into the claims of brain training programs.

Introduction

Background Information

In recent years, research has been conducted that challenges the idea that the brain is hard-wired and unable to change. This research shows that the brain is able to organize and reorganize itself in the cerebral cortex at the synaptic level substantially as a result of practice and experience (Webb & Adler, 2008). Functional MRI's have shown that other areas of the brain can take over functions lost by damaged areas in the brain (Bradley 2000). Additionally, researchers have explored the cognitive reserve hypothesis, or capability of an individual to cope with a task in order to optimize his or her performance by the recruitment of different neural networks and by using alternative cognitive strategies (Stern 2009). This discovery has led researchers to investigate how the brain changes in response to experience, and how to capitalize on this idea during rehabilitation for individuals who have had a stroke or traumatic brain injury.

The brain's capacity to change, known as plasticity, allows the brain to respond to environmental changes or change within the organism itself (Kolb 1995). There are several patterns in the brain that can change due to practice-related activities. Reorganizing the functional activations in the brain as a result of experience is the most common observation of change. There are two types of practice-related reorganization: redistribution of functional activities and functional reorganization of activations. In redistribution, the same functional areas of the brain are being activated, but contributions of each area increases or decrease as a result of practice (Kelly et al. 2006). In contrast, reorganization of activations, or "process switching" involve a qualitative change in the place of activations as a result of practice (Kelly et al. 2006). Regardless of the manner of change, understanding the plasticity of the brain is critical when assessing and implementing therapy programs for adults who have experienced an insult to the brain.

The population we are concerned with in this study is adults over age 45 who have experienced a cerebrovascular incident (CVA) or brain injury. A CVA, also known as a stroke, is currently the third leading cause of death in the United States, along with the leading cause of long term, permanent disability (americanstrokeassociation.org). Only 10% of stroke survivors recover completely, leaving 90% that need continuing therapy and rehabilitation after leaving the hospital and outpatient unit to improve motor and cognitive function (americanstrokeassociation.org).

According to Webb and Adler (2008), a CVA is an interruption of blood flow to the brain as a result of occlusive (thrombotic or embolic) or hemorrhagic mechanisms. Occlusive strokes occur when there is a blockage in an artery, which reduces or stops the flow of blood through the artery. Neurons around this area will die within a few minutes if oxygen is not restored (Cicala 1999). Hemorrhagic strokes occur when a vessel in the brain ruptures and causes a cerebral hemorrhage (Webb & Adler 2008). CVAs lead to deficient blood supply to the brain and result in brain cell death. If this happens the brain does not have the capacity to generate new neurons. Therefore once a neuron dies it will never be replaced. However research is showing the neurons in other areas of the brain can partially take over the functions of destroyed neurons (Cicala 1999). The severity and amount of damage to brain tissue is dependent upon where and how long the blockage occurs in the blood supply. The middle cerebral artery is crucial because it supplies blood to Wernicke's and Broca's area, two important areas on the left side of the brain for speech and language (Murray & Clark 2006). Tissue death in these areas causes a variety of speech and language deficits. The most common deficit is a neurogenic language disorder called aphasia.

Murray & Clark (2006) defines aphasia as “a disruption in using and understanding language following neurological injury or disruption that is not related to general intellectual decline or sensorimotor deficits (Murray & Clark 2006).” It is an impairment that affects several different linguistic processes including comprehension, speech fluency, naming, and repetition (Webb & Adler 2008).

Dysarthria is also a common speech problem that results from a stroke. Dysarthria is defined as a condition in which a person is no longer able to produce speech properly due to paralysis or muscle weakness (Biermann & Toohey 2005). It is a result of damaged nerves that serve the larynx, tongue and mouth (Burkman 1998). Deficits from this disorder may vary from slightly slurred speech to completely unintelligible. People who have dysarthria may also have dysphagia, a difficulty swallowing.

Aside from speech and language deficits, other symptoms of a stroke vary greatly depending upon which area of the brain is involved, and the actual cause of the stroke. Due to how the nervous system is organized, symptoms from left hemisphere lesions will occur on the right side of the body and vice versa. The most common impairment resulting from a stroke is hemiplegia, a weakness on one side of the body (Burkman 1998). Hearing loss can occur if the area of the temporal lobe that processes hearing is affected by the stroke. Loss of vision will also occur if the parietal lobe is damaged. Most strokes affect a person’s memory and cognition, particularly if the stroke affects the temporal lobes or areas near the thalamus (Cicala 1999). Strokes affecting a person’s non-dominant hemisphere (usually the right) will cause deficits in a person’s ability to perform specific cognitive tasks, such as working with numbers, recognizing simple geometric shapes, reading, writing, and problem solving (Biermann & Toohey 2005).

Lastly, a stroke may affect a person's ability to control his or her emotions, which may be displayed through mood swings or depression.

In this study we are also interested in adults with traumatic brain injury (TBI). Trauma is an umbrella term that includes open head injuries and closed head injuries. A bullet wound to the head is an example of the former, and a motorcycle accident is an example of the latter. 90% of traumatic brain injuries (TBI) are due to closed head injuries (Kempler 2005). The amount of damage and symptoms following trauma is dependent upon the location and severity of the incident. In open head injuries, the functions that are controlled by the direct area of insult are affected the most. On the other hand, closed head injuries cause diffuse axonal injury and numerous areas of torn nerve fibers deep in the white matter of the brain and brainstem (Bradley 2009). Unlike open head injuries, this type of TBI may cause widespread deterioration of many capacities of the brain rather than complete loss of a single neurological function. Closed head injuries can range from mild (loss of consciousness for less than 15 minutes, posttraumatic amnesia for less than an hour and no structural damages seen on an MRI) to severe (coma for more than 6 hours, bleeding within the skull, or generalized brain swelling seen on an MRI) (Cicala 1999). For our study, we are interested in the effects that mild head injuries have on individuals.

There are many long-term problems that individuals with a mild head injury experience. Some of the most common include deficits in attention, memory and executive function. Attention problems are the most apparent and affect other cognitive deficits and communication problems (Murray & Clark 2006). Memory problems are common because memory involves many different areas of the brain to work together. Injury to any area of the brain will affect a person's memory, particularly short term memory (Cicala 1999). Concentration is also impaired due to the high incidence of frontal lobe damage in head injuries (Bradley 2009).

Recovery from stroke or TBI is dependent upon the extent of damage to brain tissue and location of the damage in the brain. It also depends on how soon rehabilitation is implemented following the stroke or TBI. The goal is to have patients begin intensive therapy as soon as possible. However in the acute stages of recovery, swelling in the brain causes symptoms to appear worse than they really are. Therefore assessment and intervention are typically not conducted until 2-3 weeks post incident (Cicala 1999). The level of motivation of a patient will affect how successful rehabilitation and recovery is as well. Acute care delivered at the hospital is the most intense level or rehabilitation that involves daily therapy from several professionals such as physical, speech, and occupational therapists (Burkman 1998). These professional are all involved in the patient's therapy and aftercare plans. The amount and intensity of therapy critically affects how much a patient will benefit from therapy. Particularly with cognitive tasks, more training leads to more improvement (Jaeggi et al. 2008). Although treatment should be provided as often and intensely as possible, third party payers typically provide a limited number of treatment sessions. Therefore current researchers are investigating the effectiveness of home-exercise programs, specifically interactive computer systems.

Research studies have been performed that show the benefits of daily cognitive stimulation on memory in healthy adults. Sherry Willis et al (2006) conducted a study to research the long-term effects of cognitive training on everyday functional outcomes in older adults. The study showed cognitive training resulted in improved cognitive abilities specific to the abilities trained that continued five years post intervention (Willis et al 2006). Furthermore, playing an interactive video game gives the elderly a sense of empowerment. Using this as a tool in therapy allows the patient to feel in control and may help with mental health aspects such as depression (Gamberini et al. 2008). However the general consensus remains with regards to brain training programs is that although improvements are observed in the cognitive tasks that are trained, there is no evidence of transfer to untrained everyday tasks (Owen et al. 2010). What has not been researched is whether or not computerized programs that do not target specific cognitive skills could be beneficial for adults who have had a stroke or traumatic brain injury. Nintendo DS Brain Age 2 is an example of such a device.

Nintendo Brain Age 2 is an interactive videogame that is stimulates the brain through a series of different cognitive activities such as solving simple math problems, counting currency and unscrambling letters. The game is played using a Nintendo DS, a handheld game system. The game keeps the player motivated by unlocking new activities as the player improves. There are several advantages of using this device in addition to traditional therapy approaches. The game is readily available and can be purchased at any electronic store. It is self-motivational and is intended to be fun. Given the importance of intensity for successful therapy, motivation and a sense of empowerment as well as a sense of enjoyment are critical factors that will affect the outcome of rehab. Lastly the game does not require any previous training, and can be used by anyone. For example other family members, particularly spouses, can also play the game and provide a positive support system as well as a competitive motivator.

Although there are many potential benefits of this interactive videogame, there is no empirical evidence that suggests the game improves cognition in healthy adults or stroke survivors. Therefore, the purpose of this study is to determine whether or not consistently playing an educational videogame (Nintendo DS Brain-Age 2) can improve memory, cognition and executive function in people who have had a stroke or strokes. The hypothesis states that after 6 weeks of consistently playing the video game, stroke survivors' cognition and memory will improve to a measurable degree. My research project is part of a larger study being conducted by Dr. Jamie Mayer at Northern Illinois University, whose goal is to assess 20 stroke survivors and 20 control subjects. She also opened the study to adults who have experienced Traumatic brain injury. Currently, 10 control subjects have been assessed, and 8 out of those 10 have been analyzed. Preliminary results demonstrate no changes in memory, executive function, speed of processing, or nonverbal intelligence after consistently playing "Brain-Age 2." While this is inconsistent with Nintendo's claims, we still want to investigate whether the game will benefit those with mild brain damage following stroke or brain injury.

Methods

Participants

The participants used in this study were 5 adults, (4 male and 1 female), who have had a stroke or brain injury. Their ages ranged from 43 to 60, with a mean of 52. The control group (assessed in a different portion of this study by Stacey Benkhe) also consisted of adults, male and female, over age 45, who have not experienced a stroke or brain injury.

Measures

The following tests were chosen to assess participants cognition before and after the study: The Rivermead Behavioral Memory Test (RBMT) was administered in full as per the examiner's manual, the Test of Nonverbal Intelligence (TONI-3) was administered in full as per the examiner's manual, and the Delis-Kaplan Executive Function System (D-KEFS) was administered in only the trail-making test (All conditions 1-5), verbal fluency test (all conditions 1-3), design fluency test (all conditions 1-3), and the color-word interference test (all conditions 1-4).

Instrumentation

Statistics of our data was run in SPSS and analyzed using Repeated Measures ANOVA with age as a covariate.

Procedure

In order to measure improvement, if any, in participants, the following methods were conducted: The participant was contacted and briefed on the nature and purpose of the study. If interested, background information was gathered and a consent form was filled out. The participant was asked to fill out an APT-II questionnaire before the initial assessment session. The aforementioned tests were administered to the participant during the initial session. After the assessments the participant were taught how to play the gaming system and received a Nintendo DS gaming system with a Brain-Age 2 game for the duration of the study. The participant was instructed to play the game at home every day for 30-60 minutes for 6 weeks. A phone conference was offered at 3 weeks as a checkup. After the 6 weeks the participant was given the same three assessments. The participant was asked to fill out the APT-II questionnaire and a Nintendo Brain-Age 2 questionnaire following the completion of the study. The results of the two tests were scored and analyzed to detect improvements.

Results

	Subject 1 Pre	Subject 1 post	Subject 2 pre	Subject 2 post	Subject 3 pre	Subject 3 post	Subject 4 pre	Subject 4 post	Subject 5 pre	Subject 5 post
	79	93	97	96	119	104	89	100	94	85
T- 3	118	89	113	105	116	117	109	116	92	85
S	10	9	11	10	12	13	14	13	4	7

omp.										
S omp mbo	10	9	12	12	10	11	9	11	11	8
S VF ing	9	11	12	14	9	11	12	10	10	9
S VF CF	7	11	9	10	12	11	14	18	19	18
S VF CV	7	12	12	14	11	10	10	9	16	14
S DF osite	9	10	12	9	15	17	15	16	8	8
S DF empt	8	10	11	8	15	16	15	15	8	8
S DF st	10	13	10	10	9	8	5	10	10	11
S	5	N/A	4	7	10	11	6	11	2	3

S vs.	1	N/A	6	10	10	11	13	7	9	8

The table above is a summary of the results of the five participants that were assessed for my portion of the study. The scores for three additional stroke subjects were also used to strengthen our reliability of the results. All of the above factors were entered into a repeated measures analysis program. In a repeated measures design, each participant is exposed to all the treatments in the study, and the effects of each treatment is compared within each individual. Greater statistical precision occurs with this design, as a posed to a between-subject design, because each subject serves as his or her control and is only compared to him or herself across the treatment conditions (Maxwell & Satake 2006). For this study we ran repeated measures in ANOVA with age as a covariate. The results of the analysis showed no significant changes from pre-assessment to post-assessment, nor were there any changes within control subjects or stroke survivor subjects.

Discussion

The results of our study are explained in the following sections: Need for Strategy Training, Measuring Effects, and Ceiling Effects.

Need for Strategy Training

According to a strategy training model of remediation, a participant's success in a treatment program is dependent his or her ability to adopt strategies to effectively allocate attentional resources to the task at hand. A study conducted by Dr. Keith Cicerone in 2002 showed that teaching participants specific strategies to compensate for attention deficits during a cognitive exercise had a greater benefit than the exercises themselves (Cicerone 2002). This strategy training model may explain why our participants showed no improvements after 6 weeks of completing the brain training exercises. Teaching the subjects strategies to compensate for their attention and memory deficits while playing the Brain-Age 2 game may be more beneficial than simply expecting the subjects to play the game independently. Incorporating strategy training as a component of this study may produce measurable changes in both control and stroke subjects.

Measuring Effects

The assessments we used in this study were chosen based upon improvements that Nintendo DS claimed would occur (memory, attention processing, cognition, etc.). Our analysis showed no improvements in the areas that our assessments evaluated. One explanation for why we saw no changes may be the assessments that we chose. Perhaps different assessments, such as a simple reaction time test, may reveal changes that we did not pick up. Additionally, if improvements did occur, they may have been specific to the Brain-age exercises. A common flaw in the brain training programs is that they do not generalize into everyday untrained activities (Owen 2010). This may be the case in our study, and explains why we saw no changes in our results from pre-assessment to post-assessment.

Ceiling Effects

Ceiling effects occur when scores on a test accumulate at the high end of a distribution because the test is too easy or the dependent variable is too sensitive to the treatment used (Maxwell & Satake 2006). This may have been the case in our study considering there were no measurable differences between the pre-assessment control subjects and stroke subjects. The Nintendo DS Brain-Age 2 exercises may not have been challenging enough to improve cognition in both control and stroke subjects. Likewise, we had to choose stroke subjects with mild deficits who were able to handle the exercises. Subjects with severe to profound deficits reported frustration, confusion, and difficulty remembering to play the game (according to the subjective questionnaires). Therefore the Brain-age 2 game seemed too easy for control and mild stroke subjects, which produced ceiling effects, and too hard for severe stroke subjects. A more challenging brain training program, accompanied by a strategy training program, may generate better, more robust results.

Final Conclusions

Based on our results of this study, our final conclusion is there is no scientific evidence that playing Nintendo DS Brain-Age 2 will yield any results the game claims in both healthy adults and stroke survivors. Consumers should take caution before buying into the claims of brain training programs. What does have scientific evidence of benefit is using strategy training to compensate for attentional deficits while performing a cognitive exercise. The effectiveness of implementing strategy training as a component of a brain training program is an area of research that needs further exploration.

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